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Mechanical response of carbon fibre-reinforced polymer laminates for aero-structures subjected to simulated lightning strike

Albertino Arteiro[1], João Pedro[2], Paulo T. Gonçalves[3], Christian Karch[4]

[1] LAETA, DEMec, Faculdade de Engenharia, Universidade do Porto, Portugal. aarteiro@fe.up.pt
[2] LAETA, INEGI, Universidade do Porto, Portugal. jpedro@inegi.up.pt
[3] LAETA, INEGI, Universidade do Porto, Portugal. prgoncalves@inegi.up.pt
[4] Airbus Defence and Space GmbH, Germany. christian.karch@airbus.com

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Abstract

In protected CFRP subjected to lightning strike, while thermal effects mostly affect the topmost UD plies, damage in the bulk, where temperatures can be far from the ablation temperatures of the composite constituents, is mainly the result of the shock waves generated by the explosion of the lightning protection layer, supersonic plasma expansion and magnetic forces. In this work, a 3D modelling strategy is applied to study the effects of stacking sequence, paint layer thickness and artificial lightning parameters on the mechanical damage induced by the direct effects of lightning strikes on carbon/epoxy multi-directional laminates protected by expanded copper foil. The models show an influence of stacking sequence not only on the orientation of the damage projected area, but also on its size. In addition, no effect on the damage depth is observed, in agreement with available experimental observations. The models also show that laminates with thicker ply blocks have larger damage projected areas. The effect of paint layer thickness is then predicted, showing that thicker paint layers lead to larger damage extent, as observed experimentally. Finally, it is shown that varying the peak current and deposited energy changes the extent of damage, with the proposed models following the trends observed in experiments. Ultimately, this study demonstrates that the progress and development of reliable models that accurately predict the main effects of

lightning strikes is key to a better understanding of this phenomenon in the context of virtual testing of composite aero-structures.

Keywords:

Polymer Matrix Composites (PMCs) Damage Finite Element Analysis (FEA) Lightning strike